The Testing of Milk, Cream and Dairy By-Products by Means of the Babcock Test

Determination of the Specific Gravity of Milk
The Percentage of Acid and Casein in Milk
Adulteration of Milk by Skimming and Watering
The Percentage of Water and Salt in Butter
The Percentage of Fat and Water in Cheese

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THE TESTING OF MILK, CREAM AND DAIRY BY-PRODUCTS
BY MEANS OF THE BABCOCK TEST

INTRODUCTORY

The Babcock test derived its name from the originator, Dr. S. M. Babcock, of the University of Wisconsin. This was the first satisfactory short method for determining the percentage of fat in milk, and since it was made public in 1890 it has been widely adopted, particularly in the United States, Canada, Australia and New Zealand. It has since, with slight modification, been successfully applied in the testing of cream, skim-milk, buttermilk, whey and cheese. This test has been of immense value to the dairy industry, since it has provided a practical means of

(*a*) determining the fat production of individual cows;
(*b*) making a more equitable division of cheese factory and creamery proceeds;
(*c*) detecting abnormal losses of fat in such by-products as skim-milk, buttermilk and whey;
(*d*) detecting adulterations such as watering and skimming.

The test is quite easy to operate as no extensive training on the part of the operator is necessary. The simplicity of the test has probably been over-emphasized, producing a corresponding carelessness on the part of some operators, resulting in inaccurate tests and subsequent criticism of the method. While the test is simple to operate, *great care and accuracy must be exercised in all details of the work*, or the results will be inaccurate and misleading. The necessity of care and accuracy in operating the test cannot be over-emphasized. It has been truly said that "in operating the Babcock test there is more to learn in care than in principle."

THE TESTING OF MILK

The apparatus employed in making a test of a sample of milk consists of four pieces:—

(*a*) pipette;
(*b*) test bottle;
(*c*) acid measure or acid burette;
(*d*) centrifuge.

The Pipette

The pipette is a glass instrument used to measure the sample of milk required for testing. Two different forms of pipette are in use which are usually designated as the "ordinary pipette" and the "automatic pipette."

The ordinary pipette consists of a glass tube enlarged into a bulb about midway between the two ends (fig. 1). The lower stem of the pipette should be small enough in diameter to pass readily into the neck of the test bottle. It

should also be drawn into a small opening at the point, since if the opening is too large air bubbles will pass up the bulb when measuring the sample and thus make accurate measurement impossible.

The upper stem of the pipette is marked and the pipette filled to this mark contains seventeen and six-tenths cubic centimetres (17.6 c.c.). The pipette should be so constructed that the graduation mark is low down on the stem and quite close to the bulb.

The construction of the automatic pipette is shown in fig. 2. The novice will measure the sample more quickly and possibly more accurately with the automatic pipette than with the ordinary pipette. The automatic pipette is more likely to be broken and is more expensive.

The Milk Test Bottle

The construction of the milk test bottle is illustrated by fig. 3. The bulb of the bottle is about one and one-quarter inches in diameter, and should have a capacity of, at least, forty-five cubic centimetres (45 c.c.). The neck of the bottle is about four inches in length and is graduated to read the percentage of milk fat when the test is completed. The graduation consists of ten main divisions numbered from zero at the bottom to ten at the top. Each division represents one per cent of fat and is subdivided into five equal subdivisions, consequently each subdivision represents one-fifth or two-tenths of one per cent of fat.

The Acid Measure and Acid Burette

The acid measure (fig. 4) is a small cylinder graduated to contain seventeen and five-tenths cubic centimetres (17.5 c.c.). Frequently an acid burette (fig. 5) is used instead of the acid graduate. Each division on the scale of the burette represents 17.5 c.c. A stand with a clamp attached is used to hold the burette.

The Centrifuge

The centrifuge (fig. 6) is a machine for whirling the bottles in making the test. It is fitted with swinging pockets to receive the test bottles and when the machine is in motion the pockets assume a horizontal position. The machine is usually driven by either hand power, or by a steam jet or turbine. Hand-driven testers are usually made to receive either two, four, eight, ten or twelve bottles, while the turbine testers will usually receive either twenty-four or thirty-six bottles. The two-bottle and four-bottle hand testers are not made with a covering frame. The larger capacity hand testers are constructed with a frame (usually cast metal) which closes in the bottles when the machine is running, which aids in keeping the samples warm. Where steam is available and the amount of testing to be done will warrant the additional expense, the turbine tester is preferable as it keeps the samples hot while being revolved.

The Required Speed of the Centrifuge

The speed at which the tester should be revolved is usually stated on the machine and varies with the diameter of the circle described by *the bottom of the bottle* in revolving.

The following table of speeds for machines of different diameter is given by Farrington and Woll in "Testing Milk and its Products":—

Diameter of Circle	Number of Revolutions of Bottle per Minute
10 inches	1,074
12 "	980
14 "	909
16 "	848
18 "	800
20 "	759
22 "	724
24 "	693

Fig. 1.

Fig. 2—Up-to-date Pipette.

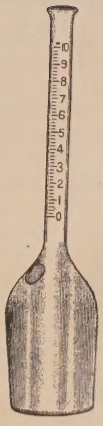

Fig. 3—Milk Test Bottle.

Fig. 4—Acid Measure.

Fig. 5.

When operating a turbine tester the speed must be ascertained by means of a speed indicator, which is applied to the spindle of the machine. The speed is regulated by varying the steam pressure used, which is indicated by steam gauge attached to the machine. The operator must determine what steam pressure on the gauge will give the desired speed to the tester.

When operating a hand-driven tester the number of revolutions which the bottle makes, to each revolution of the handle, should be determined by counting. The diameter of the circle described by the bottom of the bottle when in the horizontal running position should be measured. By consulting the above table the required speed of the bottle is obtained. The number of revolutions per minute required as indicated by the table is divided by the number of revolutions the bottle goes to each revolution of the handle. The result will be the number of revolutions of the handle per minute.

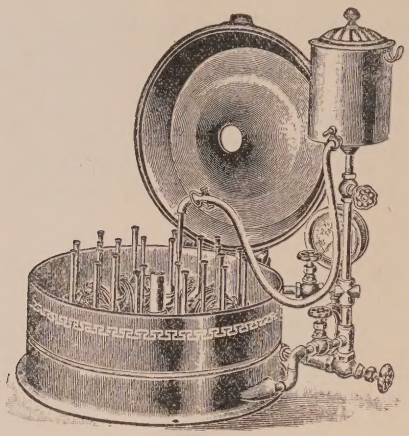

Fig. 6.

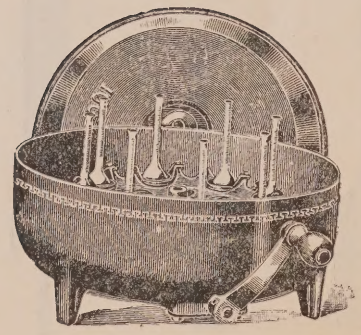

Fig. 6.

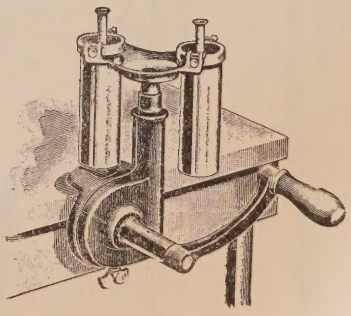

Fig. 6.

For example, if the bottle is found to complete twelve revolutions for each revolution of the handle, and the diameter of the circle described by the bottom of the bottle is fourteen inches, we find by consulting the above table that for a

fourteen-inch diameter, the bottle must revolve 909 times per minute; 909 divided by 12 is 76 (almost), which is the number of revolutions required of the handle each minute.

The tester should be placed perfectly level on a firm bench and be kept well oiled.

The Milk-Test Act

The Milk-Test Act which came into force January 1, 1911, provides that all test bottles and pipettes used, or sold to be used, for the testing of milk and cream in connection with the Babcock test must be verified by the Standards Branch of the Department of Trade and Commerce, Ottawa. Glassware, when verified and found to be *correct* within a specified limit of error, must "be ineffaceably marked with the outline of a crown having within it the initial letter of the reigning sovereign". All milk and cream test bottles and pipettes, now in use or offered for sale, must be so marked.

Making the Test

Before starting to make a test of whole milk see that all glassware to be used is clean and bears the verification mark.

Securing a Representative Sample of Milk

In testing milk it is neccessary that the sample taken for testing represents the average quality of the quantity of milk to be tested. If such is not the case, the result of the test will, of course, be inaccurate and misleading. When milk is allowed to stand for even a short time, cream rises to the surface and in order to thoroughly mix the milk before taking a sample for testing, it is best to pour the entire quantity of milk from one vessel to another several times. If the quantity is too great to permit of pouring, it should be well stirred. After being thoroughly mixed a smaller quantity (three to six ounces) should be taken out and put into a seperate vessel.

Sampling and Adding Milk to the Test Bottle

The sample should be brought to a temperature of 60° F. to 70° F. and then poured from one vessel to another several times. Care must be taken that all the cream mixes back with the milk and that none adheres to the sides of the vessel. In pouring allow the milk to follow down the side of the vessel into which it is being poured. By so doing there is less tendency to partially churn the sample which would render the results less accurate. After the sample is thoroughly mixed, if using the ordinary pipette, insert the lower stem of the pipette into the milk and by suction of the mouth raise the milk above the graduation mark on the pipette. Quickly cover the top of the pipette with the index finger, taking care to keep the top of the pipette and the finger dry. By slightly removing the finger allow the milk to drop slowly from the pipette until it comes exactly to the 17.6 c.c. graduation mark on the stem of the pipette. The lower stem of the pipette is now inserted into the neck of the test bottle and the sample allowed to run into the bottle. The last few drops should be expelled from the pipette into the test bottle by blowing through the pipette.

If using the "up-to-date" automatic pipette, have the glass petcock of the pipette open and insert the lower stem of the pipette into the milk. By suction on the tube leading from the large upper bulb, draw the milk up into the pipette until the lower bulb is filled and the milk is overflowing from the upper stem into the large bulb. While the milk is still overflowing into the large bulb, quickly close the petcock. The lower stem of the pipette is inserted into the

neck of the bottle and the petcock is opened to allow the milk to flow into the test bottle. As with the ordinary pipette the last few drops should be expelled from the pipette into the test bottle by blowing through the pipette.

It is a rather common practice for operators of the test to blow through the pipette into the milk before drawing the sample up into the pipette. This should never be done as air is incorporated in the sample which will affect the result of the test.

While the sample of milk is measured into the test bottle, the test is based on weight. The 17.6 c.c. pipette will deliver, of average milk, a definite weight —eighteen grams—into the bottle Since the weight of a given volume of milks of different richness is fairly constant, measuring with a pipette is quite accurate and does not introduce any appreciable error.

If several samples are to be tested, each sample should be given a serial number and a test bottle marked with a corresponding serial number for each sample A part of the bulb of the test bottle is usually frosted so that such a number may be written on with a lead pencil.

Adding the Acid

The next step is the addition to the test bottle of the acid which is used in making the test. Commercial sulphuric acid with a specific gravity (Sp. Gr.) of 1.82 to 1.83 is used and should be at a temperature of 60° F. to 70° F. The acid is measured in the cylinder provided for the purpose which is graduated to contain 17.5 c.c. After measuring the correct quantity of acid into the graduate it is slowly poured into the test bottle. When pouring the acid into the test bottle the bottle should be held in a slanting position and if any drops of milk are adhering in the neck of the bottle, the bottle should be slowly revolved so that the acid will carry the milk down into the bottle. By holding the bottle in a slanting position the acid flows down the walls of the bottle and lies under the milk. The acid should never be allowed to drop directly on the milk, and after adding the acid to the bottle there should be a distinct line between the milk and acid. If the bottle is placed on the table after adding the acid, care should be taken not to jar the bottle which will tend to partially mix the milk and acid.

In case the acid burette is being used it is filled with acid to the top graduation mark. The test bottle is held in a slanting position underneath the burette with the top of the burette inserted into the neck of the test bottle. By opening the petcock the acid is allowed to flow into the bottle. When the surface of the acid in the burette is lowered to the second graduation mark, the petcock is closed and 17.5 c.c. of acid will have been delivered into the test bottle.

The sulphuric acid used in making the test is extremely corrosive. It is advisable to have, at all times, a bottle of liquid ammonia at hand, and in case of any acid coming in contact with the clothing, a liberal application of the ammonia will neutralize the acid and prevent the destruction of the cloth. Should the acid come in contact with the face or hands, wash immediately with cold water.

Mixing the Milk and Acid

After adding the acid to the test bottle the milk and acid should be thoroughly mixed, shaking the bottle with a rotary motion. The neck of the bottle must not be covered with the finger while mixing the milk and acid and care should be taken to avoid splashing particles of milk or curd into the neck of the bottle. As the milk and acid are mixed the milk is first curdled, then the clots of curd are dissolved and disappear, the mixture turns a dark chocolate colour, and becomes hot, due to the action of the acid on the milk.

Placing the Bottles in the Tester

The bottle or bottles should, at once, be placed in the tester in such a way that the machine will be balanced. If an odd number of samples are being tested an extra test bottle may be filled with water and placed in the machine to properly balance it. If the machine is not properly balanced it will not run smoothly and the bottles are likely to be broken.

Keeping the Bottles Warm

If the bottles are allowed to become cool, previous to, or while whirling, an incomplete separation of fat will result and the reading will be too low. There is, of course, no difficulty in keeping the samples sufficiently warm when using a turbine tester. When using a hand machine in a cool room it is advisable to partially fill the frame of the machine with boiling water before commencing the whirlwind. When using the two, or four-bottle hand tester, which has no covering frame the pockets should be filled with boiling water surrounding the bottles.

The bottles are whirled for five minutes at the proper speed. As pointed out above, the bottle when in motion assumes a horizontal position. The bottle, rapidly revolving, is subject to a force which tends to throw it away from the centre. This is known as "centrifugal force." This force is exerted most strongly on the heaviest parts of the mixture which work to the outside, thereby forcing the fat, which is lightest, to the centre. When the whirling ceases the bottle assumer a vertical position with the fat on the surface. If the machine is not run long enough or sufficiently fast, the separation of fat will not be complete.

Adding the Hot Water to the Test Bottles

Hot water is now added to the bottle to float the separated fat up into the neck of the bottle so that the percentage may be read.

The turbine tester usually has a small pail attached for heating and adding the water to the test bottles. The pail is fitted with a small rubber tube leading from the bottom of the pail, into the end of which is fitted a piece of glass tubing drawn to a point similar to the glass of an eye-dropper. There is a spring pinch cock on the rubber tubing to shut off the water. If using a hand tester and only a few samples are being tested at one time, the pipette will answer very well for adding the water to the bottles. If many samples are being tested it is advisable to provide such a pail as described above and attached to the turbine tester as shown in fig. 6.

Rain water or condensed steam is preferable to hard water as it will give a clearer fat column in the finished test. If hard water must be used, a few drops of sulphuric acid should be added to the water before it is heated. Adding acid to hot water is dangerous as it is liable to be splashed on the face, hands or clothes of the operator.

If a turbine tester is being used a temperature of 140° F. to 160° F. will be high enough at which to have the water for adding to the bottle. If a hand machine is being used the water should be made much hotter, in fact there will be no disadvantage in using boiling water. As far as possible the work should be done in such a manner as to have the temperature of the samples between 130° F. and 140° F. when the test is completed, and the temperature of the water used may be varied somewhat with this end in view.

Sufficient water is added to fill the bottle to the bottom of the neck and the bottle whirled for one minute at the proper speed, after which water is again added until the top of the fat column in the neck is raised to about the eight per cent mark on the scale. In adding water the second time it is advisable to allow

the water to drop directly on the fat in the neck of the bottle. The water passing through the fat column tends to wash the fat and carry any impurities, which may be in the fat, down into the body of the bottle. The bottles should be again whirled for one minute.

Many operators add all the water at one time but clearer readings will usually be obtained by adding the water twice as outlined above. If the water is all added at once the bottles should be whirled for two minutes after adding the water.

Temperature of Fat when Reading the Test

The Third Dominion Conference of Dairy Experts held at Ottawa, December 6 and 7, 1911, adopted a tempertature of 130° F. to 140° F. as the proper one at which to have the fat when the percentage is read. If the fat is too hot when read, the result will be too high owing to expansion and if the fat is too cold the result will be low owing to contraction.

The Use of a Water Bath

In order to get accurate results and uniformity from time to time, the bottles should be placed in a water bath at a temperature of 130° F. to 140° F. for, at least, two minutes before the per cent of its fat is read. The water surrounding the bottles should extend up on the neck of the bottle as high as the top of the fat column. If many samples are to be tested, it is well to have a rec-

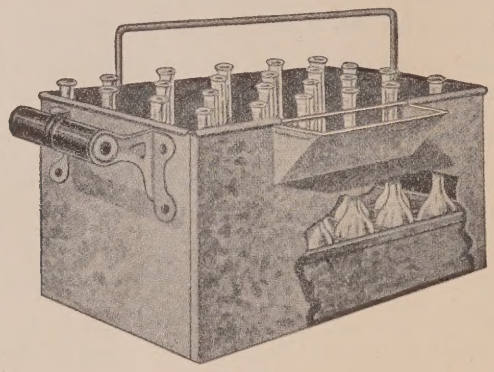

Fig. 7.

tangular tin dish (fig. 7) made to be used as a water bath for the bottles. This dish should be about one-half inch less in depth than the length of the bottles, so that the bottles cannot be overflowed with water. A false bottom in the bath, with round holes in it, or wire rack to receive the bottles, will prevent them from being overturned in the water.

Reading the Test

If the work of making the test has been properly performed, the fat column will be a bright amber colour, free from any dark or curdy specks. The top of the fat column will appear slightly hollow or concave and the bottom of the

column will appear slightly rounded or convex (fig. 8). The bottle should be held level with the eye to be read, and the reading taken from the extreme points of the fat column, that is from A to B and not from C to B. By reading

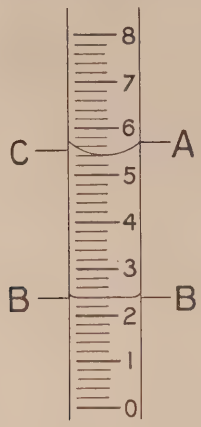

Fig. 8.

from the extreme points, allowance is made for a slight amount of fat which is not raised into the neck of the bottle, and the results will correspond more closely with chemical analyses.

The reading of the fat is most conveniently taken by means of a pair of Dividers (fig. 9), with fine, sharp points. The hinge of the dividers must be stiff enough that the dividers will not work too freely. The dividers are spread until the points are farther apart than the fat column is long, then one point is placed at the extreme lower end of the fat column, and the dividers slowly

Fig. 9.

closed until the other point is at the extreme upper end of the fat column. One point of the dividers is now placed at the zero mark on the scale and the other point will indicate on the scale the correct reading. For instance, if the length of the fat column, as shown by the dividers, is three main divisions and four subdivisions, the reading is $3\frac{4}{5}$ per cent. This may also be expressed as $3\frac{8}{10}$ per cent or 3.8 per cent. This would mean that in each one hundred pounds of such milk there are 3.8 pounds of milk fat.

Cleaning the bottles

As soon as the readings of fat are taken the bottles should, while still hot, be emptied and rinsed with warm water. They should next be thoroughly washed with hot water to which has been added a little of some good washing compound, using the brush provided to clean out the neck. The bottles should be again rinsed with hot water to thoroughly remove the washing compound from the bottle. Even with such washing the bottles will in time become

coated on the inside. To prevent this an occasional cleaning, using a very strong solution of washing compound, with some shot in the bottle, is advisable. Sulphuric acid, to which has been added as much bichromate of potash as the acid will dissolve, makes an excellent material for cleaning any dirty glassware, and the same solution may be used many times.

Dark-Coloured or Burnt Readings

If, when the test is completed, the fat column contains black specks or is too dark in colour, the test is not satisfactory and a duplicate test should be made.

Dark-coloured or burnt readings may be due to one or more of the following causes:—

(*a*) the milk, the acid, or both, being at too high a temperature (over 70°);
(*b*) too much or too strong acid;
(*c*) allowing the acid to fall directly on the milk;
(*d*) allowing the bottles to stand too long after adding the acid before mixing.

Light-Coloured or Curdy Readings

If when the test is completed the fat column is too light in colour or shows curdy, the results of the test may be too high and a second test should be made.

Light-coloured or curdy readings are due to one or more of the following causes:—

(*a*) the milk, the acid, or both, being at too low a temperature (under 60°);
(*b*) too little or too weak acid;
(*c*) not thoroughly mixing the milk and acid before whirling.

Acid supplied for testing is not always of the proper strength. If the test is carefully and properly made, *a dark-coloured or burned reading indicates that the acid is too strong, while a light-coloured or curdy reading indicates that the acid is too weak.* If the acid is only slightly too strong, satisfactory results may be obtained by using somewhat less than 17.5 c.c., and if the acid is only slightly weak, using a little more than 17.5 c.c. will give satisfactory results. Acid that is much too strong or much too weak cannot be used satisfactory. Acid, if left exposed to the air, becomes weaker by absorbing moisture from the air, consequently acid of the correct strength should be kept stoppered when not in use. Acid, which is too strong, will in time weaken to the correct strength if left uncorked. If a cork stopper is used, the acid will char the cork and the acid becomes dark. A glass-stoppered bottle is preferable.

Composite Samples of Milk

A composite sample of milk is a quantity of milk composed of several smaller samples taken from different sources and *should represent the average quality of the different quantities from which the samples are taken.*

Cheese factories, which divide the proceeds on a basis of the test, use the composite sample and the great majority test only monthly.

A tightly stoppered bottle is provided for each patron, and some means provided to identify each patron's bottle. A convenient way is to gum a label bearing the patron's name, or a number to designate the patron, to each bottle. If the label is covered with two coats of shellac, the bottle may be washed without injury to the label.

The Use of a Preservative

Some chemical is used as a preservative to prevent souring and other fermentations. Since nearly all strong preservatives suitable for this purpose are very poisonous, some colouring matter is mixed with the preservative which gives the sample a distinctive colour and thereby indicates that the sample is unfit for use as a food. Preservative may be purchased in tablet form from the dairy supply houses. These commercial tablets are usually composed largely of corrosive sublimate and are very satisfactory. Powdered corrosive sublimate is also very efficient. If this is used a small proportion of magenta should be mixed with the corrosive sublimate to colour the sample.

In case one is troubled with mould growing on the walls of the bottle a few drops of formaldehyde may be added to the sample. This will prevent the growth of mould.

The Quantity of Preservative to Use

The preservative is added to the bottle before any sample is put in. No definite quantity of preservative can be said to be the correct quantity. The correct quantity to use is the least that will preserve the sample efficiently, and this depends on

(*a*) the quantity of milk that will be in the sample bottle;
(*b*) the length of time over which a sample extends;
(*c*) the temperature at which the sample will be kept;
(*d*) the degree of ripeness of the milk composing the sample.

An excess of corrosive sublimate affects the casein in such a manner that it seems more difficult to dissolve and more shaking is required in mixing the milk and acid in the best test bottle.

Sampling Milk for the Composite Jar

The sample of milk added each day to the composite jar should not only represent the average quality of the quantity from which it is taken, but should also be proportionate to the quantity.

Two methods of taking the sample are in common use:—

(*a*) the small cone-shaped dipper (fig. 10);
(*b*) the sampling tube (fig. 11).

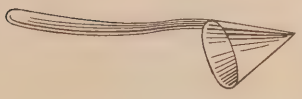

Fig. 10.

Fig. 11.

The small cone-shaped or "ounce dipper" as it is commonly called does not take a sample proportionate to the quantity of the milk being sampled. Since milk delivered at a cheese factory is well mixed from the agitation received on the wagon and by pouring into the weighing can the sample taken by the ounce dipper will represent the quality of the milk quite accurately.

The ounce dipper is much more commonly used in cheese factory work than the sampling tube owing to its greater convenience. Since the quantity and quality of milk delivered by a patron to a cheese factory is fairly uniform from day to day the use of the ounce dipper in taking samples for the composite test will not introduce any serious error.

Sampling Frozen Milk

Milk should not be allowed to freeze, but in severe weather partially frozen milk is occasionally received at cheese factories. In freezing, the fat and other milk solids not in solution are to a great extent forced out of the ice. The ice of frozen milk will frequently contain less than one per cent of fat, the fat being largely in the unfrozen portion. Consequently partially frozen milk should not be sampled until the ice has been melted and the whole quantity thoroughly mixed. It is very difficult to secure a uniform distribution of fat in a quantity of milk which has been allowed to freeze.

Mixing the Composite Samples

After adding the sample to the composite jar each day, the sample should be mixed by shaking the bottle in a rotary motion, care being taken not to splash any cream up on the walls of the bottle. If any clots of cream should be splashed on the walls of the bottle, the agitation should be continued until it is completely washed down.

Care of Composite Samples

Composite samples should be kept in a cool place and not exposed to sunlight. Neither should they be exposed to frost as it is extremely difficult to get a correct sample from the jar if the samples have been partially frozen. They should be kept tightly corked at all times since if not tightly stoppered evaporation of water takes place which will result in the test being too high.

Preparing Composite Samples for Testing

The composite sample should be prepared for testing by warming to a temperature of 100° F. to 110° F. in order to soften any clots of cream and to remove all cream from the walls of the composite jar. The temperature of the sample should not be allowed to become high enough to melt the fat into oil as it is then difficult to get a representative sample from the jar since the oil will quickly rise to the surface. The sample should be carefully poured from one vessel to another several times and the sample *immediately* taken for testing.

Testing Thick or Curdled Milk

Testing thick or curdled milk is not to be recommended as it is more difficult to get a correct sample. However in hot weather a sample may curdle due to insufficient preservation, or to over-ripe milk having been added to the jar. In such cases a very small quantity of powdered lye may be added to the sample and the sample poured from one vessel to another several times. The lye neutralizes the acid and when sufficient acid is neutralized the milk again becomes liquid. The lye should be added in small quantities, pouring the sample several times after each addition of lye. In this way the use of an excessive quantity of lye may be avoided. When the lumps of curd disappear and the sample becomes fluid it is sampled in the usual way. Samples treated in this manner require less acid than a normal sample.

THE TESTING OF CREAM

Determination of the Per Cent of Fat in Cream

Cream is that portion of milk, rich in fat, which rises to the surface of milk on standing, or is separated from it by centrifugal force.

The Babcock test is used to determine the percent of fat in cream as well as in milk. In determining the per cent of fat in cream certain modifications of the method already outlined for determining the per cent of fat in milk are necessary.

Cream Test Bottles

In testing cream specially graduated test bottles are used. Several different styles of bottles (fig. 12) are on the market, but those most commonly used are:—

(*a*) the six and one-half ($6\frac{1}{2}$) inch bottle graduated to read fifty (50) per cent of fat, using a nine (9) gramme sample;

(*b*) the six and one-half ($6\frac{1}{2}$) inch bottle graduated to read either forty (40) or fifty (50) per cent of fat, using an eighteen (18) gramme sample;

(*c*) the nine (9) inch bottle graduated to read fifty (50) per cent of fat, using an eighteen (18) gramme sample.

Fig. 12.

Each main division on the graduation scale of these bottles, representing one per cent of fat, should be subdivided into two equal subdivisions, each of which represents one-half of one per cent of fat. This is not always done and on many bottles the smallest division of the scale represents one per cent of fat.

Whether the bottle is constructed for a nine (9) gramme or an eighteen (18) gramme sample, the bulb should have a volume, at least, equal to that of the ordinary ten (10) per cent milk bottle.

Both the six and one-half-inch nine gramme bottle and the nine-inch eighteen-gramme bottle have necks of smaller bore than the six and one-half-inch eighteen-gramme bottle. In this respect either of the former is preferable to the latter, since the smaller the bore of the neck the less error there is likely to be in reading the percent of fat. In using the nine-gramme bottle, however, any error in weighing the sample produces twice as great an error in the test as the same error in weighing will produce in the eighteen-gramme bottle. This is readily seen from the following calculation:—

If a nine-gramme sample in a nine-gramme bottle reads 36 per cent fat, each one gramme of the sample reads $36 \div 9 = 4$ per cent fat, and each one-half gramme reads 2 per cent fat. If an eighteen gramme sample in an eighteen-gramme bottle reads 36 per cent fat, each one gramme of the sample reads $36 \div 18 = 2$ per cent fat, and each one-half gramme reads 1 per cent fat.

That is, an error of one-half gramme in weighing the sample produces in one case an error of 2 per cent in the reading and in the other case an error of 1 per cent.

In using the nine-inch bottle a specially constructed machine is required, which is more expensive than the ordinary tester. The nine-inch bottles are more expensive than the six and one-half-inch bottles, and breakages are more frequent, not only when whirling the bottles but also in handling, since the longer bottle is more easily overturned.

The nine-gramme bottle has an advantage over the eighteen-gramme bottle in that nine cubic centimetres of water are mixed with the nine grammes of cream, which tends to give a clearer reading.

Which bottle one shall use is largely a matter of preference on the part of the operator, as any one of the three will give satisfactory results if the work is properly done.

To secure uniform results all bottles used in any plant should be made of uniform construction, all made to test the same weight of sample and with uniform graduation and diameter of bore.

Sources of Error in Measuring Cream for Testing

As pointed out previously the Babcock test is *based on weight* and it is simply for convenience that the sample is measured with the pipette in testing milk. The pipette delivers approximately the same weight of milk from time to time. Several factors, however, tend to render measuring of cream by means of a pipette inaccurate. These are:—

(*a*) *Variation in richness of cream.*—Cream may test as low as 15 per cent of fat or as high as 50 per cent. As the per cent of fat in cream increases, the weight of a given volume decreases. Therefore a pipette, which will measure a sample of the proper weight from a low testing cream, will measure, from a richer cream, a sample that will be too light.

(*b*) *Gas and air in the cream.*—More or less gas due to souring or other fermentations is present in cream. The heavy body of the cream tends to retain these gases in the cream and therefore reduce the *weight* of cream which will be measured by a pipette. This will not have so great an influence if the cream is warmed before the sample is measured with a pipette, as the warming reduces the body of the cream so that the gas will, to a great extent, escape.

This is illustrated by the following table which also illustrates the difference between the results obtained when the scale is used to weigh the sample as compared with measuring with the pipette.

The different samples of sweet cream were tested using both scales and pipette and were then allowed to sour in tightly stoppered bottles, after which they were again tested while cold, using both scales and pipette. The samples were then warmed to 100° F. and tested using the pipette.

TABLE

—	Sweet Cream		Sour Cream		
			Cold Cream		Warm Cream
	Scales	Pipette	Pipette	Scales	Pipette
A	41·0	39·0	(No test)	41·0	39·0
B	36·5	34·5	33·5	36·5	34·0
C	32·0	31·5	31·5	32·0	31·5
D	34·0	32·5	32·0	34·5	32·5
E	36·5	35·0	34·0	36·5	35·5
F	32·0	31·5	31·0	32·0	31·5
G	35·5	34·5	34·0	36·0	35·0
H	30·0	30·0	29·5	30·0	29·5

These figures are typical of the results obtained in several more such tests. Practically no difference, beyond a reasonable limit of error, is noticed between the tests of the same cream sweet or sour, when the sour sample is warmed to 100 degrees before sampling, though in some cases a slightly lower reading is noticed where the sample was taken without warning. It is quite possible that in special cases—with very gassy cream—this error would show greater than in these figures, as these samples soured quite clean in flavour.

(*c*) *Cream adhering to the walls of the pipette.*—Some cream adheres to the walls of the pipette and if this is not thoroughly rinsed off and added to the test bottle the result of the test will be inaccurate.

The Use of Scales for Weighing Samples of Cream

In order to avoid these sources of error in measuring cream samples, scales have been devised for weighing the cream samples of either nine (9) grammes or eighteen (18) grammes into the bottles. Cream testing scales are constructed

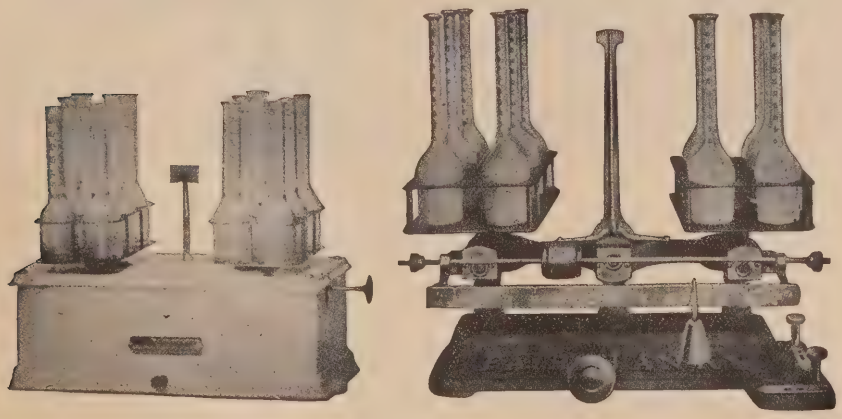

Fig. 13.

of different capacities. Some scales have a capacity of twelve test bottles (fig. 13), that is cream samples may be weighed into each of twelve bottles with one balancing of the scales. Other scales have capacities of four bottles, two bottles or one bottle (fig. 14). The fewer the bottles the scales will carry the more accurate will be the weighing and the longer will the work require since the scales must be balanced more frequently. The scales should be kept in a dry place to protect the bearings from rust which would soon render the scales inaccurate. When in use the scale should be placed on a *firm, level* shelf or table.

In using the twelve-bottle scale the bottles are numbered and placed on the scale. The weight on the weighting beam is placed at the extreme left notch on the beam and the scale is then balanced by moving the ball on the tare beam. The ball or weight on the weighting beam is then moved to the right, to the nine (9) gramme or eighteen (18) gramme mark, depending on the style of bottle being used, and cream is added to bottle No. 1 until the scales again balance. Usually the weight is again moved to the right and the weighing repeated into bottle No. 2. This is repeated until the bottles on the left pan of the scale each contain a sample, when the weight on the beam is moved to the left and samples weighed into bottles on the right arm of the scale. A better practice is to weigh a sample into a bottle on the left pan, then move the weight back to the left and weigh a sample into a bottle on the right pan, weighing alternately into bottles on the right and left pans until all bottles contain samples. The four-bottle scale is used in the same manner as the twelve-bottle scale, except that nine (9) and eighteen (18) gramme weights are used on the pans of the scale instead of the weight on the notched beam. With the one-bottle scale (fig. 14) after balancing the scale with the bottle placed on the left

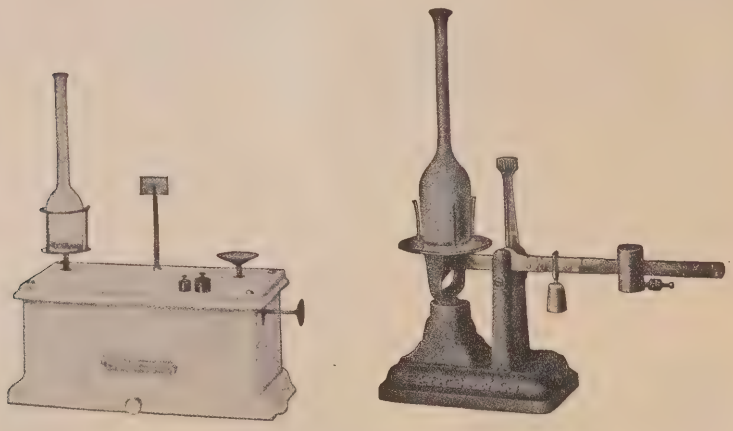

Fig. 14.

pan a nine (9) gramme or eighteen (18) gramme weight is placed on the right pan of the scale and the sample is then weighed into the bottle.

Sampling Cream for Testing

In sampling cream for testing special precautions must be taken to secure a sample which represents the average quality to be tested. It is more difficult to get a representative sample of a quantity of cream than it is to get a representative sample of an equal quantity of milk, since the cream does not mix as

readily. If circumstances permit it is best to pour the quantity of cream from one vessel to another several times. If pouring is not practicable, the cream should be thoroughly stirred by means of a stirring rod (fig 15) constructed for the purpose.

Fig. 15.

If the quantity of cream is thoroughly mixed a small dipper (fig. 10) will be quite satisfactory for taking the sample. Owing to the difficulty of thoroughly mixing a can of cream, several special devices have been recommended for taking the sample. Of these the "McKay Sampler" (fig. 11) is probably the most satisfactory. This is constructed with two slotted tubes, one inside the other. The tubes are turned to close the slot and the sampler inserted in the cream to the bottom of the can. The slot is, then, opened to admit the cream to the tube, after which the slot is closed and the tube withdrawn. The sample thus taken is a small column of cream extending from the bottom of the can to the surface of the cream, and is representative both of the *quality* and *quantity* of the cream sampled.

Preparing and Weighing the Sample for Testing

The sample of cream to be tested should be warmed to remove any lumps from the cream. Should lumps be present, which will not disappear upon warming, the sample should be poured through a fine wire strainer and the lumps broken up and forced through the strainer. The sample is then carefully poured from one vessel to another several times and, by means of a pipette, cream is transferred to the bottle on the scale until the scale balances exactly.

If using a nine (9) gramme sample in a nine (9) gramme bottle, nine cubic centimetres of water should be added to the sample in the bottle from a nine cubic centimetre pipette. The full quantity of acid (17.5 c.c.) will be required with a nine-gramme sample, if nine cubic centimetres of water have been added to the bottle. The addition of water in the bottle usually gives a clearer fat column. For the same reason it is advisable to add a few cubic centimetres of water to the eighteen-gramme sample. The addition of water, however, necessitates the use of more than the usual quantity of acid, and care must be taken not to add too much water to the eighteen-gramme sample, as the bulb of the bottle will not be large enough to hold the extra acid required in addition to the water.

Measuring Cream Samples with the Pipette

When strict accuracy is not essential fairly correct results may be obtained by using a pipette and measuring the cream into the test bottle. Since cream is lighter than milk, the pipette used for measuring the sample into the eighteen-gramme bottle should be larger than that used for testing milk. A pipette with a volume of eighteen cubic centimetres is used in connection with the eighteen-gramme bottle, and after the sample has been measured into the bottle a few cubic centimetres of warm water should be used to rinse the pipette, which rinse water is added to the bottle. For measuring the sample into the nine-gramme bottle a nine-cubic centimetre pipette is used and nine cubic centimetres of warm water is used to rinse the pipette and is added to the sample in the bottle.

As previously stated, the presence, in a cream sample, of gases due to souring or other fermentations, or of air incorporated by pouring, while introducing no appreciable error when the scales are used, will produce an appreciable error

if the pipette is used. The presence of air and gas in the cream lessens the weight delivered by the pipette. Warming the samples reduces the body or thickness of the cream, facilitating the escape of the gas or air from the sample and to a great extent prevents error from this source. For this reason especial attention should be given to the warming of the sample when the pipette is to be used.

Reading Cream Tests

Especial care should be taken to have the fat at a temperature of 130° F. to 140° F. for reading. Owing to the volume of fat present in the neck of the cream bottle, considerable error may be introduced by having the samples too hot when read. Cream samples also require longer than milk samples to become adjusted to the temperature of the water bath.

Unlike reading the tests of milk, the reading of cream tests is not taken from the extreme points of the fat column but from the bottom of the fat column to the *bottom* of the meniscus on the surface of the fat column (fig. 17). The reading should be taken from A to B, not from C to B.

The Use of Oil in Reading Cream Tests

Owing to the difficulty of determining where the bottom of the meniscus is, a few drops of a light-coloured oil is frequently added to the top of the fat column. This oil must be lighter than the fat, so that it will not mix with, but float on top of the fat. The oil is conveniently added to the bottle by means of a pipette, allowing it to flow down the wall of the neck of the bottle. The meniscus is raised up on the surface of the oil leaving a sharp distinct line between the fat column and the oil. The reading should be taken from this line to the bottom of the fat column.

This oil may be secured from any of the leading dairy supply houses, or may be prepared by any one requiring it. A mineral oil sufficiently light that it will not mix with the fat must first be secured. An oil sold, by one of the leading companies, under the trade name " Albolite " is very satisfactory. Alkanet root, which may be obtained from any good drug house, is used to colour the oil. One ounce of alkanet root will colour one gallon of oil. The alkanet root should be rolled in double ply cheese cloth and soaked for twenty-four hours in the oil. The alkanet root is then removed and the oil will be of a light reddish colour and ready for use.

Composite Samples of Cream

While many creameries, and the number is increasing, test each delivery of cream received from each patron, many still use the composite samples and test either once or twice each month.

What has been said regarding composite samples of milk will also apply to composite samples of cream.

The ounce dipper is not as satisfactory for sampling cream as for sampling milk. Since it is more difficult to thoroughly mix cream than milk and since the deliveries of cream show greater variation both in quality and quantity than deliveries of milk some such device as the McKay sampler already described should be used.

Evaporation of Water from Composite Samples of Cream

Especial care should be taken to see that the sample jars are tightly corked to prevent evaporation of water from the jar, which would cause the samples to test too high.

To illustrate this point, some years ago the writer after testing a number of composite cream samples at the end of a month left the samples uncorked in a cold room for seventeen days and again tested the samples. The tests were as follows:—

	At end of Month	Seventeen days later
A	40.0	48.0
B	25.0	28.0
C	40.0	42.0
D	30.0	31.0
E	21.0	24.0
F	30.0	32.5
G	29.5	34.0

These figures illustrate plainly the necessity of keeping the composite jars tightly corked. The extreme variation in sample A, is accounted for by the fact that there was very little cream in the jar and the evaporation was higher proportionally than in the other jars.

Testing of By-Products

Determination of the per cent of fat in skim-milk and buttermilk

Under the most favourable conditions of separation and churning of cream there is some fat lost in the skim-milk and the buttermilk. The Babcock test may be used to determinate the extent of these losses.

Fig. 16.

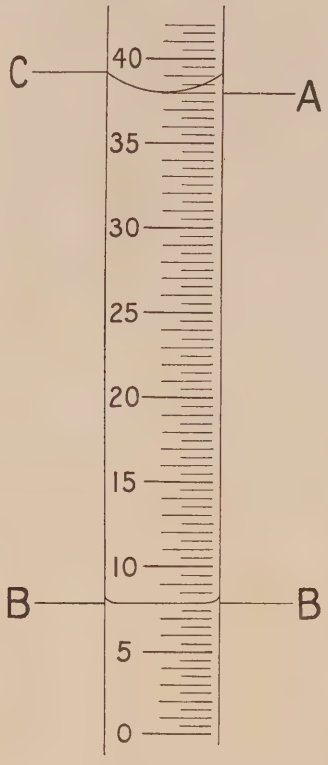

Fig. 17.

THE DOUBLE-NECK BOTTLE

A specially constructed double-neck bottle (fig. 16) is used. The larger neck is to admit the skim-milk or buttermilk and acid to the bottle and should be conducted down close to the bottom of the bottle. The smaller neck is graduated to read the percentage of fat. The older style of double-neck bottle was usually graduated so that the entire scale consisting of ten divisions represented one-half of one per cent of fat. Each division would, therefore, represent five one-hundredths of one per cent of fat.

Most double-neck bottles now on the market have either five or ten main divisions, each of which represents five one-hundredths of one per cent of fat and is subdivided into five equal divisions. Each small division, therefore, represents one one-hundredth of one per cent of fat.

In testing skim-milk or buttermilk special care must be taken to have all glassware perfectly clean, as a slight amount of fat in the pipette or bottle would seriously affect the results.

A 17.6 c.c. pipette is used to measure the sample and 17.5 c.c. of acid is ordinarily used. It is probable that a slightly more perfect separation of the fat will be obtained if the milk and acid are cooled below 60° F. and about 20 c.c. of acid used.

Care must be taken in mixing the milk and acid to avoid closing the graduated neck of the bottle with small pieces of curd. If this occurs the mixture of milk and acid will be forced out of the other neck and the work must then be repeated. It is a good practice to add half the acid, and mix, then add the remaining half of the acid and mix again. The water must be added slowly to avoid forcing the fat out of the neck. If necessary when reading the test, the fat can be raised by pressing the finger over the opening of the larger neck.

In testing skim-milk or buttermilk the fat is not all recovered in the neck of the bottle. Some fat remains in the mixture of milk and acid. It has been recommended that five one-hundredths of one per cent be added to the reading shown on the bottle to allow for this error and thus make the test correspond more closely with chemical analyses. However, since the fat remaining in the mixture in the bottle cannot be recovered by mechanical means and is, therefore, not available for the manufacture of cheese or butter, and since the testing of these by-products is largely to determine the *comparative* loss from time to time, such addition to the reading would seem to be unnecessary.

DETERMINATION OF THE PER CENT OF FAT IN WHEY

The double-neck bottle and 17.6 c.c. pipette are used in testing whey. Care should be taken to have the temperature of the whey well down to 60° F. Owing to the fact that part of the milk solids have been removed in the process of cheese-making less acid is required and usually slightly over half a measure of acid will be sufficient.

THE AVERAGE COMPOSITION OF MILK, SKIM-MILK, BUTTERMILK AND WHEY

——	Milk*	Skim-milk†	Buttermilk†	Whey†
	Per cent	Per cent	Per cent	Per cent
Water	87·5	90·30	90·6	93·40
Fat	3·6	0·10	0·1	0·35
Casein	2·5	2·75	2·8	0·10
Albumen	0·7	0·80	0·8	0·75
Sugar	5·0	5·25	4·4	4·80
Ash	0·7	0·80	0·7	0·60
Lactic acid	.....	.....	0·6	

* Dean. † Van Slyke.

Per cent—	Butter*	Cheese**
Water	13.0	32.06
Fat	83.5	34.43
Casein	1.0	28.00
Salt and ash	2.5	5.51

* Van Slyke. ** Shutt.

DETERMINATION OF THE SPECIFIC GRAVITY OF MILK

By specific gravity (Sp. Gr.) is meant the weight of a definite volume of any substance as compared with the weight of an equal volume of some other substance chosen as a standard, both being at the same temperature.

In determining the specific gravity of liquids or solids, pure distilled water is taken as a standard and the specific gravity of water is represented by 1.

One gallon of water weighs ten (10) pounds. If one gallon of sulphuric acid is found to weigh eighteen (18) pounds, the specific gravity of the acid is found by the following calculation:—

When a volume of water weighs 10 pounds an equal volume of sulphuric acid weighs 18 pounds.

When a volume of water weighs 1 pound an equal volume of sulphuric acid weighs $18 \div 10 = 1.8$ pounds.

This means that the acid is 1.8 times as heavy as water or has a specific gravity of 1.8.

The Use of Hydrometers

The specific gravity of a liquid is not usually obtained by weighing a definite volume of the liquid, but it is obtained by means of an instrument known as an hydrometer. The hydrometer is a glass instrument which floats upright in the liquid constructed with a small bulb on the lower end, which is loaded with either mercury or fine shot, and a larger hollow bulb above, to the top of which is attached a slender stem with a graduated paper scale inside from which to read the specific gravity. The use of such an instrument for determining the specific gravities of liquids is based on the natural law that "A body floating in a liquid will displace a volume of that liquid equal in weight to the weight of the body floating". The hydrometer sinks in the liquid until it has displaced a volume of the liquid equal in weight to the weight of the hydrometer. In constructing hydrometers for determining the specific gravities of different liquids, the weight of shot or mercury in the lower bulb, and the size of the hollow bulb above, are varied, depending on the specific gravity of the liquid or liquids to be tested. The greater the specific gravity of the liquid or liquids to be tested, the heavier must the hydrometer be loaded in proportion to the size of the hollow bulb. The reading on the graduated stem is taken just at the surface of the liquid. The lighter the liquid, the farther will the hydrometer sink into the liquid, and the heavier the liquid, the higher up will the hydrometer float.

Since liquids expand and become lighter when warmed, and contract and become heavier when cooled, an hydrometer will only give a correct reading when used in a liquid at the temperature for which it is constructed to be used.

The Lactometer

Such an hydrometer is used to determine the specific gravity of milk and is usually called a lactometer. The lactometer commonly used in determining the specific gravity of milk is known as the "Quevenne" locometer. It is

usually constructed as a combined thermometer and hydrometer (fig. 1) and is constructed to give a correct reading when used in milk at a temperature of 60° F.

Fig. 1.

The scale on the lactometer is usually graduated from 14 at the top to 42 at the bottom and each of the twenty-eight (28) divisions between 14 and 42 is called a lactometer degree.

Fig. 2.

If the lactometer is constructed as a combined thermometer and hydrometer, the thermometer scale should be *above* the lactometer scale in the stem, so that the temperature may be read when the lactometer is at rest in the milk.

In taking the lactometer reading of milk, a glass or tin cylinder about one and one-half inches in diameter and twelve inches high (fig. 2) is necessary. To be strictly accurate, the milk should be brought to a temperature of 60° F. and after carefully pouring the milk from one vessel to another a few times to distribute the fat uniformly throughout the milk, the cylinder is filled with milk to within about one and one-half inches of the top. The clean, dry lactometer is now gradually lowered into the milk in the cylinder until it comes to rest and floats steadily in the milk. The point on the scale which shows at the surface of the milk is at once read and recorded and is known as the lactometer reading (L.R.).

The Influence of Different Temperatures

As pointed out above, as the temperature of the milk is raised above 60° F. (the temperature at which the lactometer is constructed to be used) the milk expands and becomes less dense; consequently, the lactometer must sink farther into the milk to displace its own weight. Since the lactometer scale is graduated from 14 at the top to 42 at the bottom, the lower the lactometer sinks the lower is the reading. On the other hand, as the temperature of the milk is reduced below 60° F. the milk contracts and becomes more dense and the lactometer does not sink as low in the milk to displace its own weight. This means a higher reading on the graduated stem than if the temperature was at 60° F.

In order to avoid the necessity of bringing the temperature of each sample of milk to exactly 60° F., the lactometer reading is usually taken at whatever temperature the milk may be, provided it is between 50° F. and 70° F. It will be found that if a sample of milk has a lactometer reading of say 30 at a temperature of 60° F., the sample will have a lactometer reading of approximately 29 at a temperature of 70° F. and of approximately 31 at a temperature of 50° F. From this, a rule for making corrections to the lactometer reading on account of the temperature being above or below 60° F. is deducted, viz., for each degree that the temperature exceeds 60° F. and 1/10 or .1 to the lactometer reading and for each degree that the temperature is less than 60° F. subtract 1/10 or .1 from the lactometer reading.

For example, if a sample of milk shows a lactometer reading of 29.5 at 67° F., the correct reading would be 29.5+0.7=30.2; and if a sample shows a lactometer reading of say 31.5 at 52° F., the correct reading would be 31.5—0.8 = 30.7. This rule gives fairly acurate results when the temperature at which the reading is taken ranges between 50° F. and 70° F., but if strictly accurate results are desired, it is best to bring the temperature of the milk to exactly 60° F. before taking the lactometer reading so that no correction on account of temperature will be necessary.

In taking a lactometer reading of a sample of milk, the milk should not be allowed to stand after pouring, before taking the reading. If the sample is allowed to stand, the cream rises to the surface and the bulb of the lactometer will be in partially skimmed milk which is heaver than the whole milk; consequently, the lactometer will not sink as deeply into the milk, giving a lactometer reading which will be too high.

The lactometer reading of milk should not be taken until milk is at least two or three hours old, as the lactometer reading of fresh milk will usually be about one degree lower than it will be from two to three hours later.

Obtaining the Specific Gravity from the Lactometer Reading

In order to obtain the specific gravity of milk from the lactometer reading, 1,000 is added to the lactometer reading and the result is divided by 1,000. That is:—

$$\frac{\text{L.R.} + 1000}{1000} = \text{Specific Gravity.}$$

For example, if the correct lactometer reading is 30, the specific gravity will be

$$\frac{30 + 1000}{1000} = \frac{1030}{1000} = 1.030$$

In order to obtain the lactometer reading of milk from the specific gravity, the specific gravity is multiplied by 1000 and 1000 is substracted from the result of the multiplication. That is, the lactometer reading = (Sp. Gr.×1000) —1000.

For example, if the specific gravity of a sample of milk is 1.029, the lactometer reading is (1.029×1000) —1000=1029 — 1000=29.

The specific gravity of normal milk usually ranges between 1.029 and 1.034, and will average about 1.0315.

DETERMINATION OF THE PER CENT OF SOLIDS NOT FAT AND TOTAL SOLIDS IN MILK

The solids of milk consist of fat, casein, albumen, sugar and ash. These total solids (T.S.) are frequently divided and referred to as "Fat" and "Solids other than fat," or "Solids not fat" (S.N.F.). The percentage of fat is determined by means of the Babcock test.

Calculating the Percentage of Solids not Fat in Milk

The percentage of solids not fat in milk is calculated from the percentage of fat and the lactometer reading. Several different formulas have been worked out for calculating the percentage of solids not fat. The one most commonly used is to add the percentage of fat to the lactometer reading at 60° F. and divide the result by 4.

$$\%\ \text{S.N.F.} = \frac{\%\ \text{Fat} + \text{L.R. at } 60°}{4}$$

For example, if a sample of milk tests 3.5 per cent of fat with a lactometer reading of 31.5 at 60°.

$$\% \text{ S.N.F.} = \frac{3.5 + 31.5}{4} = \frac{35}{4} = 8.75$$

Another formula commonly used is to multiply the per cent of fat by 0.2, divide the lactometer reading by 4 and add the two results:—

$$\% \text{ S.N.F.} = \text{Fat} \times 0.2 + \frac{\text{L.R.}}{4}$$

Using this formula with a sample testing 3.5 per cent fat and having a lactometer reading of 31.5, the calculation is as follows:—

$$\% \text{ S.N.F.} = 3.5 \times 0.2 + \frac{31.5}{4}$$
$$= 0.7 + 7.875.$$
$$= 8.575.$$

This latter formula is slightly more complicated to use, but is more accurate than the former.

Determination of the Per Cent of Total Solids

The per cent of total solids may be obtained by adding the per cent of solids not fat to the per cent of fat. For example, if a sample of milk is found to contain 4 per cent fat and 9 per cent solids not fat, the per cent of total solids is 4+9=13.

THE DETECTION OF ADULTERATION OF MILK BY MEANS OF SKIMMING, WATERING OR BOTH, AND CALCULATION OF THE EXTENT OF ADULTERATION

The detection of adulteration by means of skimming, watering, or both, and the calculation of the extent of the adulteration is dependent on the effect of such adulteration on the per cent of fat, on the lactometer reading or specific gravity, and on the per cent of solids not fat of the milk.

The specific gravity of water is 1.0, of fat about 0.9, of whole milk usually from 1.029 to 1.034, with an average of about 1.0315, of skimmed milk from 1.032 to about 1.037.

The Effect of Skimming or Partially Skimming Milk

It will be readily understood that removing part of the cream from milk will cause the milk to test lower in fat content. Since fat has specific gravity of 0.9, which is considerably less than the specific gravity of milk, removing part of the fat from milk by means of skimming will cause the partially skimmed milk to have a higher specific gravity or higher lactometer reading than the whole milk had before being partially skimmed. Roughly speaking, for each one per cent of fat removed by skimming, the lactometer reading of the partially skimmed milk will be increased by about one degree.

For example, if a sample of milk tests 4 per cent fat and has a lactometer reading of 32, removing 1 per cent of fat, that is, skimming it down to 3 per cent of fat, will increase the lactometer reading to about 33. Applying the formula

$$\% \text{ S.N.F.} = \frac{\% \text{ F.} + \text{L.R. at } 60°}{4}$$

to both the pure sample and the partially skimmed sample, we find the per cent of solids not fat is 9 in each case. That is, if the lactometer reading increases 1 degree with each 1 per cent of fat removed by skimming, the per cent of solids not fat would not be affected. In actual practice, it is usually found that partially skimming milk slightly increases the per cent of solids not fat.

Skimming milk, therefore, reduces the per cent of fat, increases the lactometer reading, and leaves the per cent of solids not fat normal or slightly high.

The Effect of Adding Water to Milk

If a sample of milk contains 4 per cent of fat with a lactometer reading of 32 (that is a Sp. Gr. of 1.032) and 9 per cent solids not fat, one gallon of such milk will weigh 10.32 pounds. If one gallon of this milk is mixed with one gallon of water, we will have two gallons of watered milk which will contain 2 per cent of fat (one-half of 4 per cent) and 4.5 per cent solids not fat (one-half of 9 per cent). Since a gallon of water weighs 10 pounds the two gallons of milk and water will weigh 20.32 pounds, and one gallon of such milk and water will weigh 10.16 pounds, or have a Sp. Gr. of 1.016 or a lactometer reading of 16. From this we see that adding water to milk reduces the per cent of fat, the lactometer reading and the per cent of solids not fat, *all three being reduced in equal proportions.*

The Effect of Both Skimming and Watering Milk

If a sample is both skimmed and watered, the watering reduces the per cent of fat, the lactometer reading and the per cent of solids not fat, and all are reduced in the same proportion. The skimming would reduce the fat still further, increase the lactometer reading and either not affect or only slightly increase the per cent of solids not fat. The result will be a low per cent of fat, a lactometer reading normal or low (more frequently low), and a low per cent of solids not fat, *with the fat reduced in greater proportion than either the lactometer reading or per cent of solids not fat.*

To recapitulate:—

Skimming is indicated by—

(*a*) low per cent of fat,
(*b*) high lactometer reading,
(*c*) normal or slightly high per cent of solids not fat.

Watering is indicated by—

(*a*) low per cent of fat,
(*b*) low lactometer reading,
(*c*) low per cent of solids not fat, *all three being reduced in equal proportion.*

Watering and skimming is indicated by—

(*a*) low per cent of fat,
(*b*) lactometer reading may be normal, but is more usually low,
(*c*) low per cent of solids not fat, *the fat being reduced in greater proportion than either the lactometer reading or per cent of solids not fat.*

If a sample of milk appears to be adulterated, a control sample should, if possible, be secured; that is, a sample from the same herd, milked in the presence of the inspector or person making the test. The control sample serves as a

basis of comparison and if the original sample shows a marked inferiority to the control sample, it will be fairly conclusive proof of adulteration. There may be, under ordinary conditions, in the milk of individual cows, variations from day to day of at least one per cent of fat and one-half per cent of solids not fat. The variations will not be so great in the milk of herds, and the larger the herd the less will the variations be. In comparing the original sample with the control sample, reasonable allowance, taking into consideration the number of cows, must be made for this natural variation from day to day.

At times there will be a wide variation in the fat content in the night's and morning's milk of herds. Particularly is this the case when the milking is not done at the same hour night and morning. When the periods between milkings are not equal, the richer milk will be obtained after the shorter period, and the variation in fat content between the two milkings will frequently exceed one per cent. The effect of irregular milking on the lactometer reading is, however, not so marked.

Determination of the Extent of Adulteration by Skimming

In samples which are simply skimmed, the pounds of fat removed from each hundred pounds of the milk is obtained by substracting the per cent of fat in the skimmed sample from the per cent of fat in the pure sample. For example, if the skimmed sample tests 2.7 per cent fat and the control sample tests 4.0 per cent fat: 4.0—2.7=1.3 pounds of fat removed from each hundred pounds of the skimmed milk. Therefore, the pounds of fat removed from each 100 pounds of milk=per cent fat in control sample—per cent of fat in the adulterated sample.

Determination of the Extent of Adulteration by Watering

In calculating the per cent of foreign or extraneous water present in a watered sample, either the fat, the lactometer reading, or the solids not fat might be used as a basis of calculation since all are reduced in the same proportion, but since the solids not fat are less subject to variation from day to day than either the per cent of fat or the lactometer reading, the calculation is based on the solids not fat. To illustrate, if we have a watered sample showing 3.0 per cent fat, a lactometer reading of 24 and 6.75 per cent solids not fat, and a control sample showing 4.0 per cent fat, a lactometer reading of 32 and 9 per cent solids not fat, to determine the per cent of foreign water, the calculation is as follows:—

There are 9 pounds solids not fat in 100 pounds pure milk.

" is 1 " " " $\frac{100}{9}$ " "

" are 6.75 " " " $\frac{100 \times 6.75}{9} = 75$ pounds pure milk.

That is 6.75 pounds solids not fat are present in 75 pounds pure milk, and since we have 6.75 pounds solids not fat in 100 pounds of adulterated milk, it is evident that 75 pounds of pure milk have been increased to 100 pounds by the addition of water. That is in each 100 pounds of *watered milk* there are 100—75=25 pounds of foreign water or 25 per cent of foreign or extraneous water.

Since the calculation is similar in all cases, we may deduce the following formula:—

$$\text{The per cent of the extraneous water} = \frac{\text{per cent solids not fat in adulterated sample} \times 100}{100 - \text{per cent solids not fat in the pure sample.}}$$

That is, to find the per cent of extraneous water, multiply the per cent of solids not fat in the adulterated sample by 100, divide the product of this multiplication by the per cent of solids not fat in the pure sample and subtract the result of this division from 100. The difference will be the per cent of extraneous water present.

Determination of Extent of Adulteration of Milk Both Skimmed and Watered

In case a sample is both skimmed and watered, the above formula for determining the per cent of foreign water present, holds good.

To illustrate, if we have an adulterated sample showing 2 per cent fat, a lactometer reading of 22, and 6 per cent solids not fat, and a control sample showing 4 per cent fat, a lactometer reading of 32 and 9 per cent solids not fat, it is plainly evident that the adulterated sample is both skimmed and watered since while the fat is reduced by one-half (from 4 per cent to 2 per cent) the lactometer is only reduced about one-third (from 32 to 22) and the solids not fat are only reduced one-third (from 9 per cent to 6 per cent).

Applying the above formula, we have the per cent of the extraneous water=

$$100 - \frac{6 \times 100}{9} = 100 - 66\tfrac{2}{3} = 33\tfrac{1}{3}.$$

The determination of the per cent of fat abstracted by skimming depends on the facts, that skimming does not to any extent affect the per cent of solids not fat, and that watering reduces the fat and the solids not fat in the same proportion. The problem is, therefore, one of proportion.

With 6% of solids not fat we have 2% fat.
" 1% " " " $\frac{2}{6}$
" 9% " " " $\frac{2 \times 9}{6} = 3\%$ fat.

That is, the water which will reduce the per cent of solids not fat from 9 per cent to 6 per cent will reduce the fat from 3 per cent to 2 per cent, or the $33\frac{1}{3}$ per cent of water is responsible for reducing the fat from 3 per cent to 2 per cent and the sample was skimmed from 4 per cent to 3 per cent, that is, 1 per cent of fat was skimmed off.

From this we may deduce the following formula: In a skimmed and watered sample, the per cent of fat abstracted=% fat in the pure sample—

$$\frac{\%\text{fat in adult. sample} \times \%\text{ solids not fat in pure sample.}}{\%\text{ solids not fat in adulterated sample.}}$$

That is, if a sample is both skimmed and watered, to find the per cent of fat abstracted, multiply the per cent of fat in the adulterated sample by the per

cent of solids not fat in the pure sample. Divide the product of this multiplication by the per cent of solids not fat in the adulterated sample and subtract the result of this division from the per cent of fat in the pure sample. The difference will be the per cent of fat abstracted.

If a sample appears to be both skimmed and watered, and one cannot tell by inspection whether the fat and solids not fat are reduced in the same proportion or not, this formula may be applied. If the milk is from a herd, and the calculation shows over 0.5 per cent fat abstracted, it is fairly good proof of skimming. If the fat abstracted shows under 0.5 per cent, the difference may be due to the natural variation in the per cent of fat from day to day, and one would not be safe in saying definitely that the milk had been skimmed as well as watered.

THE DETERMINATION OF THE PER CENT OF ACIDITY IN MILK

The determination of the per cent of acid in milk is based on the facts that acids and alkalis neutralize each other in definite proportions and that certain chemicals known as indicators may be used to denote by a change of colour in the liquid being neutralized, the exact point at which all the acid and all the alkali are neutralized. This is known as the neutral point. The method of determining the per cent of acid in milk consists of neutralizing the acid in a definite volume of the milk by means of an alkaline solution (usually caustic soda) of *known strength* and using a solution of phenolphthalein which is colourless in acids and pink in alkalis, as an indicator. By measuring the quantity of alkaline solution of known strength used to neutralize the acid in a given volume of milk, and by knowing the proportions in which caustic soda and lactic acid neutralized each other (which is 40 grammes of caustic soda to 90 grammes of lactic acid) the per cent of acid in the milk may be calculated. In order to avoid the necessity of calculating the per cent of acid in each sample tested, the alkaline solution is made of such a strength that each cubic centimetre of solution used will neutralize 1/10 per cent or 0.1 per cent of lactic acid in a 10 c.c. sample of milk. This strength of solution is known as a one-ninth normal $(\frac{n}{9})$ solution, and consists of four and four-ninths $(4\frac{4}{9})$ grammes of chemically pure caustic soda in 1,000 c.c. of solution.

The standard alkaline and the indicator solutions may be obtained from the dairy schools and agricultural colleges throughout the country.

The test for determining the per cent of acid in milk is termed the acidimeter and the apparatus (fig. 3) employed in making such a test consists of:—

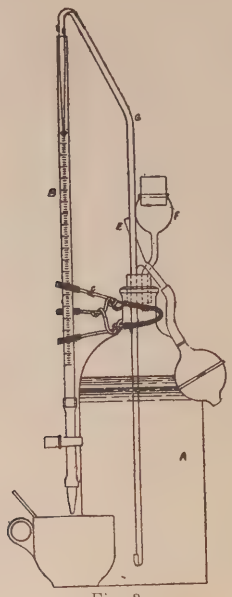

Fig. 3.

1. A 10 c.c. burette, preferably one with a blue line down the back to ensure accuracy of reading, and a glass stop-cock. The burette should be graduated to 0·1 c.c.
2. A clamp for holding the burette.
3. A 10 c.c. pipette known to be correct. Since many of the 10 c.c. pipettes sold are not accurate, the pipette should be tested for accuracy by comparison with the 10 c.c. burette.
4. A delf cup or glass beaker.
5. A glass stirring rod.
6. A dropper bottle for the indicator solution.
7. A bottle for the standard alkaline solution.

Protecting the Alkaline Solution from the Air

The alkaline solution must be protected from the air since if exposed to air it weakens, due to the neutralization of the alkali by the carbonic acid of the air. The most common form of acidimeter is arranged to syphon solution through glass and rubber tubing from the bottle into the burette. The air admitted to the bottle to replace the solution drawn out, is first passed through the alkaline solution in a small "wash bottle" to neutralize the carbonic acid. This method of protecting the solution from the carbonic acid has not been entirely satisfactory. Prof. W. O. Walker, of Queen's University, Kingston, Ont., has recommended covering the surface of the solution in the bottle with kerosene which prevents air from coming in contact with the solution.

Making the Test

In determining the per cent of acid in a sample of milk, one should first see that all glassware is perfectly clean. The sample is poured to ensure uniformity and by means of the 10 c.c. pipette, 10 c.c. of milk is measured and delivered into the cup or beaker. The pipette should be rinsed with a few cubic centimetres of distilled water or clean rain water, and the rinse water added to the cup. Three to five drops of the indicator solution are now delivered from the dropper bottle into the cup and the burette filled with solution to the 0 mark on the graduation scale, care being taken that no air remains in the tip of the burette. Solution is now carefully dropped from the burette into the milk in the cup, and the milk and solution constantly mixed by stirring with the glass rod. The solution is added until a faint pink colour is obtained uniformly throughout the mixture, which indicates that the neutral point has been reached. If one ceases adding the solution at the correct point, this faint pink colour will disappear in a few seconds due to the action of the carbonic acid on the air. *Sufficient solution should not be added to make the pink colour permanent, as the neutral point will have been passed and the mixture in the cup will be decidedly alkaline.* The number of cubic centimetres of solution drawn from the burette is now noted, and each 1 c.c. used represents 0·1 per cent of acid in the milk; therefore, to determine the per cent of acid in the milk, multiply the number of cubic centimetres of solution used by 0·1. For example, if 2·1 c.c. of solution have been used, the per cent of acid in the milk equals 2·1 x 0·1 =0·21.

Preparation of the Alkaline Solution

As previously stated, the alkaline solution is a caustic soda solution of strength known as $\frac{n}{9}$, which means that in each 1,000 c.c. of the solution there are 4⅑ grammes of chemically pure caustic soda. Owing to the difficulty of getting caustic soda absolutely pure and free from moisture, the solution is not prepared by weighing out a definite quantity of caustic soda and dissolving the same in a definite volume of water. A $\frac{n}{9}$ acid (usually hydrochloric) solution is prepared by a trained chemist and the alkaline solution made of such a strength that the $\frac{n}{9}$ acid solution and the alkaline solution neutralize each other in equal volumes; that is, 10 c.c. of the $\frac{n}{9}$ acid solution will exactly neutralize 10 c.c. of the alkaline solution. The alkaline solution will then be $\frac{n}{9}$.

The cheese or butter maker who wishes to prepare the standard alkaline solution for himself should secure a quantity of the standard $\frac{n}{9}$ acid solution from one of the dairy schools or agricultural colleges or from a trained chemist. Obtain the best quality of caustic soda and distilled water or clean rain water. If a delicate scale and gram weights are available, 5 grammes of caustic soda may be weighed out for each 1,000 c.c. of solution it is desired to make. For

every 5 grammes of caustic soda used, 1,000 c.c. of water is measured out and the soda dissolved in the water. Since a $\frac{n}{9}$ – caustic soda solution consists of 4⅑ grammes of caustic soda in 1,000 c.c. of the solution, the solution obtained by dissolving 5 grammes in 1,000 c.c. of water will be too strong, provided the caustic soda is reasonably pure. In standardizing the alkaline solution, it is best to make it too strong at first and then reduce the strength by adding water, rather than to have it too weak at first and have to increase the strength by adding more caustic soda. Two 10 c.c. burettes should be used in standardizing the solution, one to measure the acid solution and one to measure the alkaline solution. If two burettes are not available, the acid solution may be measured with the pipette and the alkaline solution measured with the burette. Have all glassware thoroughly clean and after the caustic soda is thoroughly dissolved and mixed in the water, the burette to measure the acid, or the pipette, if only one burette is available, should be thoroughly rinsed with the acid solution. Ten cubic centimetres of the acid solution are delivered from the acid burette or pipette into the cup or beaker and three to five drops of indicator solution added. The burette for measuring the alkaline solution is rinsed two or three times and filled to the 0 mark with the alkaline solution already prepared. The alkaline solution is slowly dropped into the acid and constanty stirred until the *neutral* point is reached. The number of cubic centimetres of solution used should be noted and the neutralization performed a second time to verify the accuracy of the result. If the alkaline solution is too strong less than 10 c.c. will be required to neutralize the 10 c.c. of standard acid solution. For example, if 9.2 c.c. of alkaline solution neutralize 10 c.c. of acid solution the alkaline solution is too strong and .8 c.c. of water must be added to each 9.2 c.c. of solution. By measuring the volume of solution prepared, the necessary volume of water to add may be calculated. For example, if there are 5,000 c.c. of the solution, the water to be added would be $\frac{5000}{9.2} \times .8 = 435$ (almost). This volume of water is now added to the solution, which is thoroughly mixed and tested for accuracy. If the work has been carefully done, the solution should be of the correct strength that is 10 c.c. of the alkaline solution should exactly neutralize 10 c.c. of the acid solution. If the alkaline solution proves to be still too strong, more water must be added, if too weak more caustic soda must be added. In standardizing the alkaline solution, two or more tests should be made each time to ensure accuracy. As soon as the correct strength is obtained, the alkaline solution should be tightly corked in a glass bottle or bottles. Earthen jugs are not suitable as containers for the solution. If the solution is not being prepared in a bottle, but in some other vessel, the bottle or bottles to receive it should be thoroughly clean and rinsed with a little of the solution before being filled.

If a delicate scale and gramme weights are not to be had, the caustic soda may be dissolved in a little water, making a strong solution. This strong solution may be gradually added to the water, testing after each addition of the strong solution. If too much of the strong solution is added and the solution being prepared is made too strong, it is reduced by adding water. The solution can soon be brought to the correct strength in this matter.

STRENGTH OF INDICATOR SOLUTION

The strength of the phenolphthalein solution used as an indicator may be varied considerably without affecting the results of the tests and different strengths of solutions have been recommended by different authorities. Prof. Walker has recommended the use of a 1 per cent solution in connection with the

Walker method of determining the per cent of casein in milk and such solution is also satisfactory for use in connection with the acidimeter. A 1 per cent solution is prepared by dissolving 1 gramme of phenolphthalein in 100 c.c. of 95 per cent alcohol.

TESTING CREAM, SKIM-MILK, BUTTERMILK AND WHEY

The acidimeter is also used to determine the per cent of acid in cream, skim-milk, buttermilk and whey in the same manner as it is used in determining the per cent of acid in milk.

DETERMINATION OF THE PER CENT OF CASEIN IN MILK BY MEANS OF THE WALKER CASEIN TEST

In determining the per cent of casein in milk by means of the Walker method, the acidimeter as described in this bulletin is used. In addition to the acidimeter, it is necessary to have:—

1. A 16.3 c.c. pipette.
2. A 2 c.c. graduate.
3. A bottle of neutral formaldehyde solution (40 per cent).

The neutral formaldehyde solution is prepared by adding a few drops of phenolphthalein indicator to the bottle of commercial formaldehyde and then adding the $\frac{n}{9}$ caustic soda solution until a faint permanent pink colour is obtained.

Making the Test

In making the test, first secure a representative portion of the milk to be tested. After thoroughly pouring this portion, take a sample with the 16.3 c.c. pipette and deliver the sample into a white delf cup or beaker. Add about 1 c.c. of indicator (1 per cent solution) and add the alkaline solution as in testing for acidity until a decided permanent pink colour is obtained. Now add 2 c.c. of the neutral formaldehyde solution, which destroys the pink colour in the sample. The burette is again filled to the 0 mark with the alkaline solution, after which the solution is again added to the cup or beaker until a permanent pink colour of the same shade as in the first operation is obtained. The number of cubic centimetres of solution used in the second operation is noted and will represent the per cent of casein in the milk. For example, if 2.5 c.c. of solution are used, the per cent of casein in the milk is 2.5.

The neutral formaldehyde solution should be kept perferably in a glass-stoppered bottle. In time the faint pink colour of the formaldehyde solution will disappear, owing to the action of the carbonic acid of the air, when a few drops of the alkaline solution should again be added to the formaldehyde to restore the colour.

Using slightly more than 2 c.c. of formaldehyde solution in making the test will not in any way affect the results.

In case a 16.3 c.c. pipette is not obtainable, the 10 c.c. pipette may be used and the test performed as outlined. The number of cubic centimeters of solution required in the second neutralization must be multiplied by the factor 1.63 to give the per cent of casein when the 10 c.c. pipette is used.

To avoid necessity of this multiplication for each sample tested when using the 10 c.c. pipette, the following table has been prepared by the originator of the test:—

$\frac{n}{9}$ c.c. – alkali used	Per cent casein	$\frac{n}{9}$ c.c. – alkali used	Per cent casein
1.00	1.63	1.35	2.20
1.05	1.71	1.40	2.28
1.10	1.79	1.45	2.36
1.15	1.87	1.50	2.44
1.20	1.95	1.55	2.53
1.25	2.04	1.60	2.61
1.30	2.12		

DETERMINATION OF THE PER CENT OF CASEIN IN MILK BY MEANS OF THE HART CASEIN TEST

The apparatus employed in determining the per cent of casein in milk by means of the Hart casein tester (fig. 4) consists of:—

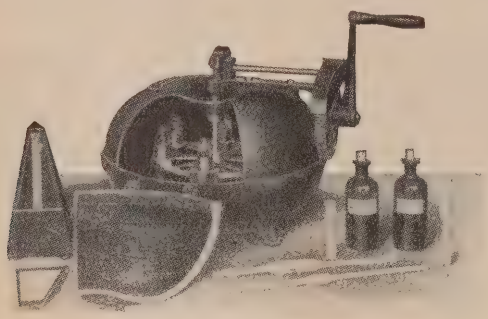

Fig. 4.

1. Centrifuge.
2. Metronome.
3. One pipette, 20 c.c. capacity.
4. One pipette, 5 c.c. capacity.
5. One graduate, 2 c.c. capacity.

The chemicals employed in making a test are chloroform of the best quality and a 0·25 per cent solution of acetic acid.

The centrifuge is constructed to receive either six or twelve bottles, the bottoms of which describe a 15-inch circle when revolving. The bottles are revolved 2,000 times per minute and the machine is so geared that the crank must revolve 55 to 56 times per minute to impart the necessary speed to the bottles.

The metronome is used to enable the operator to turn the crank at a uniform speed of 55 to 56 turns per minute.

The 20 c.c. pipette is used to measure the dilute acetic acid solution, the 5 c.c. pipette is used to measure the milk sample and the 2 c.c. graduate is used to measure the chloroform in making the test.

The bottle is constructed with the graduated stem on the lower end and the bulb on the upper end. The graduation of the scale is similar to that of the 10 per cent Babcock milk test bottle.

Preparation of Acetic Acid Solution

The dilute acetic acid solution is prepared by adding 90 c.c. of distilled water to 10 c.c. of chemically pure glacial acetic acid. To 25 c.c. of this 10 per cent solution are added 975 c.c. of distilled water, making 1,000 c.c. of a 0·25 per cent solution.

Making the Test

In making the test, the temperature of the milk, the chemicals, and room in which the work is being performed should be between 65° F. and 75° F.—preferably at 70° F.

By means of the small graduate 2 c.c. of chloroform are measured and transferred to the test bottle, and by means of the 20 c.c. pipette, 20 c.c. of the dilute acetic acid are also added to the test bottle. The sample of milk to be tested is carefully poured to ensure uniformity, and by means of the 5 c.c. pipette, a 5 c.c. sample is taken and added to the chloroform and acid in the test bottle. The mouth of the bottle is tightly covered with the thumb and the bottle inverted and carefully shaken for fifteen to twenty seconds, which is timed by means of a watch.

Tests should be made in duplicate and should be whirled as soon as possible after being shaken. If more than one sample is being tested, the chloroform and acid are added to all bottles and then the sample of milk added to each bottle, after which all are shaken.

The bottles are placed in the machine in such a manner that the machine is properly balanced. The metronome is now set to beat fifty-five to fifty-six beats per minute and the crank is turned fifty-five to fifty-six revolutions per minute for seven and one-half to eight minutes.

The bottles are now taken from the machine and placed in a perpendicular position in a rack made for the purpose.

In the lower part of the graduated tube, there is now a liquid which is composed of the chloroform and fat. Above this is the casein, which should appear as a solid white column free from ragged edges, and above the casein is the acetic acid mixed with the remaining portion of the milk.

After the bottles have been allowed to stand ten minutes, the per cent of casein is read from the graduated scale.

The test is very sensitive to changes in conditions under which it is operated. Increasing the temperature of the milk, the chemicals, or the room in which the work is performed, will give lower readings, while decreasing the temperature of the milk, the chemicals, or the room, will give higher readings. Decreasing the speed of the centrifuge will give higher readings, while increasing the speed will give lower readings.

THE TESTING OF BUTTER

Determination of the Per Cent of Water in Butter

As the principles which determine the percentage of water incorporated in butter have become better understood by buttermakers, a gradual increase in the water content has been apparent. Since it is unlawful to manufacture or to sell butter in Canada containing more than sixteen per cent of water, a simple, rapid and reasonably accurate means of determining the percentage of water in butter has become a necessity for the guidance of the buttermaker as well as for inspection purposes.

Method of Determining the Per Cent of Water in Butter

Some of the moisture tests which have been put on the market have been complicated and lacked durability. The method most commonly used in Canada at the present time, consists of the evaporation of the water from a definite weight of butter and the determination of the percentage of water from the loss in weight.

To avoid the necessity of computing the per cent of water from the loss in weight, scales have been constructed to give, when a definite weight of butter is used as a sample, the per cent of water directly from the beam used to balance the scale after the evaporation of the water from the sample. Different makes of scales are on the market which differ greatly in construction, but the principle of the moisture determination is the same.

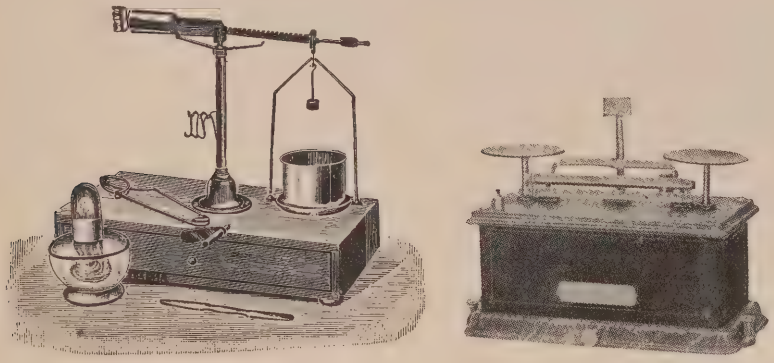

Fig. 5.

The apparatus (fig. 5) used in making a moisture determination, consists of:—

(*a*) the scales;
(*b*) a cup usually made of aluminium in which to heat the sample;
(*c*) some device to hold the sample cup while heating;
(*d*) an alcohol lamp with which to heat the sample.

Sampling Butter for Testing

In testing butter for moisture as in testing milk or cream for fat, a sample must be secured which represents as closely as possible the average quality of the quantity to be tested. In taking a sample from the churn, the surface of the mass should be cut away with a spade and a small piece of butter taken from the interior of the mass. Repeat this several times, taking samples from different parts of the churn. Sampling solid boxes, tubs or crocks is best done by means of a trier; taking three or more plugs from different parts of the package. In sampling pound blocks or prints, a good method is to cut out a quarter section of the print, cutting lengthwise of the print. The quarter section may be cut into two pieces, one of which is taken as a sample.

Preparing the Sample for Testing

When the sample is secured, it should be placed in a clean dry glass jar and the jar surrounded with warm water to soften the butter. The butter should be stirred with a spoon until it is reduced to a creamy consistency and all lumps

disappear. The butter should not be reduced to an oil, as the water and salt will settle to the bottom and it is then very difficult to get a representative sample from the jar for testing. If the sample becomes oily, it is difficult to get duplicate tests to agree.

Making the Test

In making a test, the cup in which the sample is heated should be perfectly clean and wiped dry. It is then heated over the alcohol lamp to dry it thoroughly and placed on the pan of the scale. After the cup is cool, the scale is balanced by adjusting the weight on the tare beam. Ten grams of butter are weighed into the cup from the sample in the jar. The cup is now heated slowly over the lamp to evaporate the water from the sample. The heating should proceed slowly so as not to char the fat, and while being heated the butter should be agitated by shaking the cup with a rotary motion. Care must be taken that no fat is splashed out of the cup. The evaporation will be accompanied with more or less noise from the sample. As soon as the noise ceases and just as the butter commences to take on a more amber colour, the heating should be discontinued, as all the water will have been evaporated. Should the heating be continued beyond this point, the residue will be charred and the result of the test will be too high. As soon as the heating is concluded, the cup is placed on the scale pan and allowed to cool. The scale does not balance now since the sample is lighter, owing to the evaporation of the water. The weights on the beam are now adjusted so that the scale balances exactly and the percentage of water is read from the beam.

When the hot cup is placed on the scale pan, an upward current of air is set up, due to the cup heating the surrounding air. This upward current of air tends to raise the scale pan. Consequently, if the reading is taken while the cup is still hot, it will be too high, since the weights must be moved farther over on the beam to counteract the effect of the air current.

The high pressure oven described under the "Determination of the Per Cent of Water in Cheese" furnishes a most satisfactory method of evaporating the water from the sample of butter.

A method of heating the sample by using a paraffin bath has also been advocated and widely used. The cup containing the butter to be heated is placed in a second cup which is surrounded by paraffin. A small copper kettle contains the paraffin which is heated to a temperature of 175° C. (347° F.) which temperature is maintained during a period of five to seven minutes. This method avoids danger of over-heating the sample, but lengthens the time required to make the test. Experience has shown that heating directly over the lamp, when carefully done, is quite accurate as compared with chemical analysis.

As with cream testing scales, the scales used for the testing of butter should be kept in a dry place.

DETERMINATION OF THE PER CENT OF SALT IN BUTTER

The method of determining the percent of salt in butter is somewhat similar to determining the per cent of acidity in milk and cream.

The method of determining the salt content of butter is based on the fact that salt and silver nitrate neutralize each other in definite proportions. The salt contained in a definite quantity of butter is washed out and dissolved in a definite quantity of water. A definite volume of the salt solution thus obtained is measured out by means of a pipette and the salt in it neutralized by titrating with a silver nitrate solution of known strength, using a potassium chromate solution as an indicator, to determine when the neutral point is reached.

Pipettes of different volumes have been recommended for measuring the salt solution and corresponding different strengths of silver nitrate solutions. Of the different modifications of the method which have been suggested, that outlined in Circular No. 14 of the University of Wisconsin by J. L. Sammis, seems to be the most adapted to our conditions. In this method, a silver nitrate solution, prepared by dissolving five and one-tenth (5·1) grammes of chemically pure silver nitrate in two hundred and fifty cubic centimetres of distilled water, and a potassium chromate solution, prepared by dissolving seven and one-quarter (7·25) grammes of potassium chromate in twenty-five (25) cubic centimetres of distilled water are used.

PREPARATION OF THE SILVER NITRATE SOLUTION

Solutions of the above strength may be procured from the dairy schools, or may be prepared by the buttermakers. The silver nitrate and potassium chromate may be procured from any good drug house. The moisture scales in use read to one-tenth of one per cent of moisture, using a ten-gramme sample, which means that the scales are sensitive to one-hundredth of one gramme. Such scales are sufficiently sensitive for weighing the silver nitrate and potassium chromate in making the solutions used in the salt test. It will be best to provide a set of gramme weights for use in connection with the moisture scale. If a set of gramme weights are not available, ten and two-tenths (10·2) grammes of silver nitrate may be weighed and dissolved in five hundred (500) cubic centimetres of water. To weigh ten and two-tenths grammes using the Torsion moisture scale, place a small piece of parchment paper on the right pan of the scale and have the sliding weight on the ten per cent beam placed at the ten per cent mark. Next balance the scale by adjusting the sliding weight on the tare beam. After balancing the scale, place the ten-gramme weight on the left pan and move the sliding weight on the ten per cent beam back to the eight per cent mark. Ten and two-tenths (10·2) grammes of silver nitrate will be required to balance the scale as it is weighed on to the paper. When using a Funke moisture scale, hang the ten-gramme weight on the scale as in balancing to weigh a sample of butter, and place one of the heavier weights used in reading the per cent of moisture on the two per cent notch of the beam. Now place the small piece of parchment paper on the pan and add shot or other heavy substance to the pan of the scale underneath the paper until the scale is almost balanced. Complete the balance by means of the poise on the end of the beam. Remove both weights and add silver nitrate to the paper until the scale balances exactly. The ten and two-tenths (10·2) grammes of silver nitrate are transferred to a clean, brown glass bottle, fitted with a ground glass stopper. Five hundred (500) cubic centimetres of distilled water or clean rain water are now added to the bottle and as soon as the crystals are thoroughly dissolved and the bottle shaken, the solution is ready to use.

Protecting Silver Nitrate Solution from Sunlight

The silver nitrate solution, if exposed to sunlight gradually weakens, and the object of using a brown glass bottle as a container is to protect the solution from the sunlight. In addition to this the bottle should, when not in use, be wrapped in brown paper and kept in a dark cupboard. The same precautions should be taken to protect the silver nitrate crystals from light. Owing to the effect of light on the solution, it is advisable for the creamery man to provide a set of gramme weights so that five and one-tenth (5·1) grammes may be weighed, which will make two hundred and fifty (250) cubic centimetres of solution. The solution will then be made more frequently and there will be less liability of it becoming weak.

Preparation of Potassium Chromate Solution

The potassium chromate solution as pointed out above, is prepared by dissolving seven and one-quarter (7·25) grammes of potassium chromate in twenty-five (25) cubic centimetres of water. If the gramme weights are not to be had, ten (10) grammes of the potassium chromate may be weighed on the moisture scale and dissolved in thirty-five (35) cubic centimetres of water. Since the 17·6 c.c. pepette *delivers* about 17·5 c.c. two measures of the pipette will give the required volume of water.

The appliances required for making a salt test are:—

(*a*) a scale for weighing a ten (10) gramme sample of butter. The moisture scale is used for this purpose;
(*b*) a cylindrical measuring glass about one and one-half ($1\frac{1}{2}$) inches in diameter and twelve (12) inches high, graduated to hold two hundred and fifty (250) cubic centimetres;
(*c*) a 17·6 c.c. pipette;
(*d*) a small glass beaker;
(*e*) a ten (10) cubic centimetre burette with glass stop-cock graduated to one-tenth ($\frac{1}{10}$) of one (1) cubic centimetre and clamp for holding the burette;
(*f*) a dropper bottle for the potassium chromatic indicator;
(*g*) a one-pint wide mouth glass bottle.

Making the Test

A sample of butter is secured and prepared for testing in the same manner as for a moisture test. The scale is balanced with a small piece of parchment paper on the pan and ten (10) grammes of the prepared sample weighed out on the paper. The paper and butter are transferred to the pint bottle and two hundred and fifty (250) cubic centimetres of water (preferably soft) at a temperature of 110° F. to 120° F. measured in the graduate and added to the bottle containing the butter. The bottle is thoroughly shaken to melt the butter and wash out the salt. After allowing the bottle to stand a few minutes, it is again shaken to ensure an even distribution of the salt throughout the water. The bottle is then allowed to stand until the fat comes to the surface. The 17·6 c.c. pipette is inserted into the solution of salt, blowing through the pipette until the end of the pipette is below the surface of the water to prevent the liquid fat rising into the pipette. The pipette is filled to the graduation mark with the salt solution and this quantity is transferred to the beaker. To the salt solution in the beaker is added one drop of the potassium chromate solution from the dropper bottle. The burette is filled to the top of the scale with the silver nitrate solution, care being taken no air bubbles remain in the tip of the burette. The silver nitrate solution is now slowly dropped from the burette into the beaker, which is shaken constantly to mix the silver nitrate solution with the salt solution. As soon as a permanent faint reddish-brown colour is obtained, the addition of the silver nitrate solution should cease as the salt is all neutralized. The number of cubic centimetres of silver nitrate solution required to neutralize the salt is read from the burette. Each cubic centimetre of solution used represents one per cent of salt in the butter. Thus if two and nine-tenths (2·9) cubic centimetres of solution are used, the butter contains two and nine-tenths (2·9) per cent of salt.

Nearly all well waters contain more or less salt and for this reason are not suitable for use in making the silver nitrate solution. Condensed steam from a boiler also contains impurities which render it unfit for use for this purpose.

Clean rain water will give more satisfactory results than either well water or condensed steam from a boiler.

If well water is used to remove the salt from the butter in making the test, it should be tested for salt in the same manner as the salt solution from the butter is tested. Whatever percentage of salt is present in the well water should be deducted from the result of the test of the butter. For example, if the well water shows 0.5 per cent of salt and the butter shows 3.5 per cent of salt, the correct test of the butter is 3.5—0.5 per cent=3.0 per cent since 0.5 per cent of salt has been added with the water. Condensed steam from a boiler should not be used at all in making the test. Well water to be mixed with the sample of butter should not even be heated by turning live steam into it. The well water may be conveniently heated by surrounding a small pail or jar of the well water with hot water.

THE TESTING OF CHEESE

Determination of the Per Cent of Fat in Cheese

The per cent of fat in cheese is most easily determined by means of the Babcock test.

Sampling Cheese for Testing

Sampling cheese for testing is conveniently done by means of a trier sufficiently long to bore half way through the cheese. Secure two plugs from each end of the cheese, taking the plugs from points distant from the edge of the cheese by about one-third of its diameter. These plugs may be cut lengthwise in strips and a small portion of each plug taken. The small portions of the different plugs are thoroughly spread out and mixed by means of a knife and plate, or mortar and pestle.

Making the Test

By means of a cream-testing scale, four and one-half grammes of the prepared sample may be weighed into a 10 per cent milk-test bottle, or nine grammes into a cream bottle. Sufficient hot water is added to bring the quantity in the bottle up to about 18 grammes. The bottle is shaken until the cheese and water are thoroughly mixed and all lumps of cheese disappear. The sample is now cooled to 70° F. and 17.5 c.c. of acid added and the test completed in the usual manner. If a 9-gramme sample has been used in a 9-gramme cream bottle, the reading on the neck of the bottle will be the per cent of fat. If a 9-gramme sample has been used in an 18-gramme bottle, the reading must be multiplied by 2 to get the per cent of fat, and if a 4.5 gramme sample has been used in a 10 per cent milk bottle, the reading must be multiplied by 4; that is, the per cent of fat is obtained by multiplying the reading by the number of grammes for which the bottle is constructed and dividing the result by the number of grammes used in making the test.

Determination of the Per Cent of Water in Cheese

The per cent of water in cheese is determined by evaporating the water from a definite weight of cheese and calculating the per cent from the loss in weight.

If steam under pressure is available, the most satisfactory method of determining the per cent of moisture in cheese by means of the high pressure

oven (fig. 6.), which is constructed of cast-iron or boiler plate, and is double-jacketed on four or five sides. It is fitted with a steam inlet to admit live steam to the space in the jacketed walls and an outlet to drain off the condensed water. The chamber is fitted with a perforated rack on which to place the samples and which permits free circulation of the warm air around the samples.

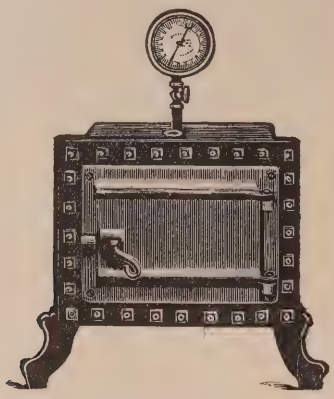

Fig. 6.

The oven is fitted with a close-fitting door and a thermometer extending into the chamber. The temperature maintained in the oven may be regulated by the steam pressure applied in the hollow walls. In addition to the oven, a fine balance is necessary or a good moisture scale and a set of gramme weights. In using the Funke moisture scale with a 10-gramme sample, a reading of 39.8 per cent of moisture may be taken, but with a Torsion scale only 30 per cent may be read without the extra gramme weights.

Making the Test

The sample of cheese to be tested is secured in the same manner as for fat determination. The sample is thoroughly spread out by means of a knife and plate, or a mortar and pestle, and 10 grammes are weighed into an aluminum or tin dish, which has been thoroughly dried by heating and then balanced on the scale after cooling. The cheese is spread as *thinly* and as *evenly* as possible over the dish. The work of sampling, pulverizing and weighing the cheese into the dish should be done as quickly as possible, to avoid loss of water by evaporation. The dish containing the sample is now placed in the oven, the door closed, and 45 to 50 pounds steam pressure applied to the oven. This should give a temperature of 225° F. to 250° F., which will be sufficiently high. The sample is heated until all the water has been evaporated, which point is determined by successive weighings followed by further heating in the oven, of course allowing the sample to cool before weighing each time. When the sample ceases to lose weight, the water is all evaporated and the per cent of moisture is determined from the loss in weight. The grammes of moisture evaporated multiplied by 10 will give the per cent of moisture. For example, if the 10 grammes of cheese lose 3.5 grammes of water from evaporation, 100 grammes would lose 100 divided by 10 and multiplied by 3.5, which equals 35 grammes, or 35 per cent.

If steam under pressure is not available, an oven constructed of tin or copper, double-jacketed on five sides, fitted with a perforated rack and close-fitting door will answer. The oven is filled with water between the walls, which water is kept boiling by means of a gas jet or alcohol lamp. Since a lower temperature (boiling) is employed with this oven than with the high-pressure oven, longer time is required to dry to constant weight.

IN CONCLUSION

To one who has carefully read the foregoing pages it will, no doubt, seem that the manipulation of the tests described is quite simple. While such is the case, extreme care and accuracy must be exercised in all details of the tests in order to secure accurate results. Many of the details in connection with the making of these tests seem unnecessary to the careless operator, but the neglect of a few minor details in making the tests means the difference between accuracy and inaccuracy. It is not uncommon for instructors of milk testing to find students without previous experience in testing doing more accurate work during the first few days of their training than they do some weeks later. "Familiarity breeds contempt," and as some operators become more familiar with the tests, the work is less carefully and less accurately performed. To slightly change the old axiom: "Eternal care is the price of accuracy."

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The following publications of the Department of Agriculture relating to Dairying are available on application to the Publications Branch, Department of Agriculture, Ottawa:—

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33 Cow Testing.
41 Cheese Factory and Creamery Plans with Specifications.
53 Buttermaking on the Farm.
58 The Progress of Cow Testing.
14 N.S. Testing of Milk, Cream and Dairy By-Products by Means of the Babcock Test.
16 N.S. Small Cold Storages and Dairy Buildings.
34 N.S. Dairying in New Zealand and Australia.

PAMPHLETS

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